Chapter 1

Veto

FIXME: *Text largely stolen from the Depth Document*

The most important reason for locating sensitive detectors deep underground is to eliminate the background events caused by cosmic ray muons that originate in the atmosphere of the Earth. Muons are the most numerous cosmic ray charged particles at the surface of the Earth. They are produced in the upper atmosphere by the collision of cosmic ray primaries (protons, and nuclei); and they lose about 2 GeV in the atmosphere before reaching the surface.

Only muons and neutrinos penetrate to significant depths underground. The muons produce tertiary fluxes of photons, electrons, and hadrons. The goal of the underground laboratory is to reduce all such sources of backgrounds by shielding the detectors under rock. The shielding is commonly expressed as either ft of standard rock (with density of 2.65 gm/cc) or in meters-waterequivalent (mwe). As muons penetrate underground they lose energy by ionization and by radiative processes.

xxx Stick table 1 of the depth document here.

1.0.1 Depth Requirements for Physics

1.0.1.1 Accelerator Neutrinos

The high granularity of the detector will allow removal of cosmic muons from the data introducing a small (¡0.1%) inefficiency to the active detector volume, so that most of the accelerator induced events are unobscured. The rate of muons in the detector at the 800 level is xxx kHz. The drift time of the TPC is 1.6ms and we propose to to acquire data for one drift before and after the arrival of the beam signal, resulting in a live time of 4.8ms. During this time, xxx cosmic rays will pass through the active volume of the detector, resulting in a timing rejection factor of xxx 10^n. If a cosmic ray muon (photon) event mimics a contained in-time neutrino event it will be rejected based on pattern recognition.

In summary, a cosmic ray veto is not required to study accelerator neutrino interactions.

1.0.1.2 Nucleon Decay

The depth requirement for proton decay experiments is dominated by the livetime loss due to event overlap with cosmic ray muons. A liquid argon detector will have much less deadtime loss at shallow depths than a water cherenkov detector as the fine segmentation in space and drift time allow one to exclude regions of the detector around each passing muon. Bueno et al.[12] estimate an effective loss of detector mass of less than 4% for a 100 kT liquid argon detector with mountainous overburden of only 200 m with the use of a veto.

The most serious source of nucleon decay background for the νK^+ mode are K^0_L mesons produced by cosmic ray spallation in the rock surrounding the detector. These neutral kaons may enter the detector and produce a K^+ via charge exchange.

Add some text here explaining that a LAr TPC has good sensitivity to this channel. xxx

The veto described in the following section is designed to reduce the background in the νK^+ mode to a negligible level.

1.0.1.3 Solar Neutrinos

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1.0.1.4 Supernova Burst Neutrinos

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1.0.1.5 Supernova Relic Neutrinos

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1.1 Veto Description

The system consists of two ”Hell Raiser” side vetos along the length of the detector and two, more conventional, veto systems at each end of the detector.

The Hell Raiser veto consists of a matrix of holes drilled into the walls of the cavern as shown in Figure xxx. The holes extend from the central detector cavern to the side galleries. A pipe containing liquid scintillator and wavelength shifting fiber is installed in each hole. The hole configuration is designed to provide the highest tagging efficiency for muon angles with the highest rate (vertical). The optical fiber readout system is adopted from the Nova experiment.

Description of the efficiency here. xxx

A conceptual layout for the end veto detectors is shown in Figure xxx. These are conventional, high efficiency, particle tracking detectors. We assume that these are liquid scintillator detector modules similar to those developed for the Nova experiment.

A description of the DAQ for the veto system goes here.